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Pacific Northwest Environmental Research Lab, Corvallis, Oreg

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U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT

ON

HARRY D. STRUNK RESERVOIR

FRONTIER COUNTY

NEBRASKA

EPA REGION VII

WORKING PAPER No. 556

WITH THE COOPERATION OF THE

NEBRASKA DEPARTMENT OF ENVIRONMENTAL CONTROL

AND THE

NEBRASKA NATIONAL GUARD

AUGUST, 1976

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Nebraska Department of Environmental Control for professional involvement, to the Nebraska National Guard for conducting the tributary sampling phase of the Survey, and to those wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

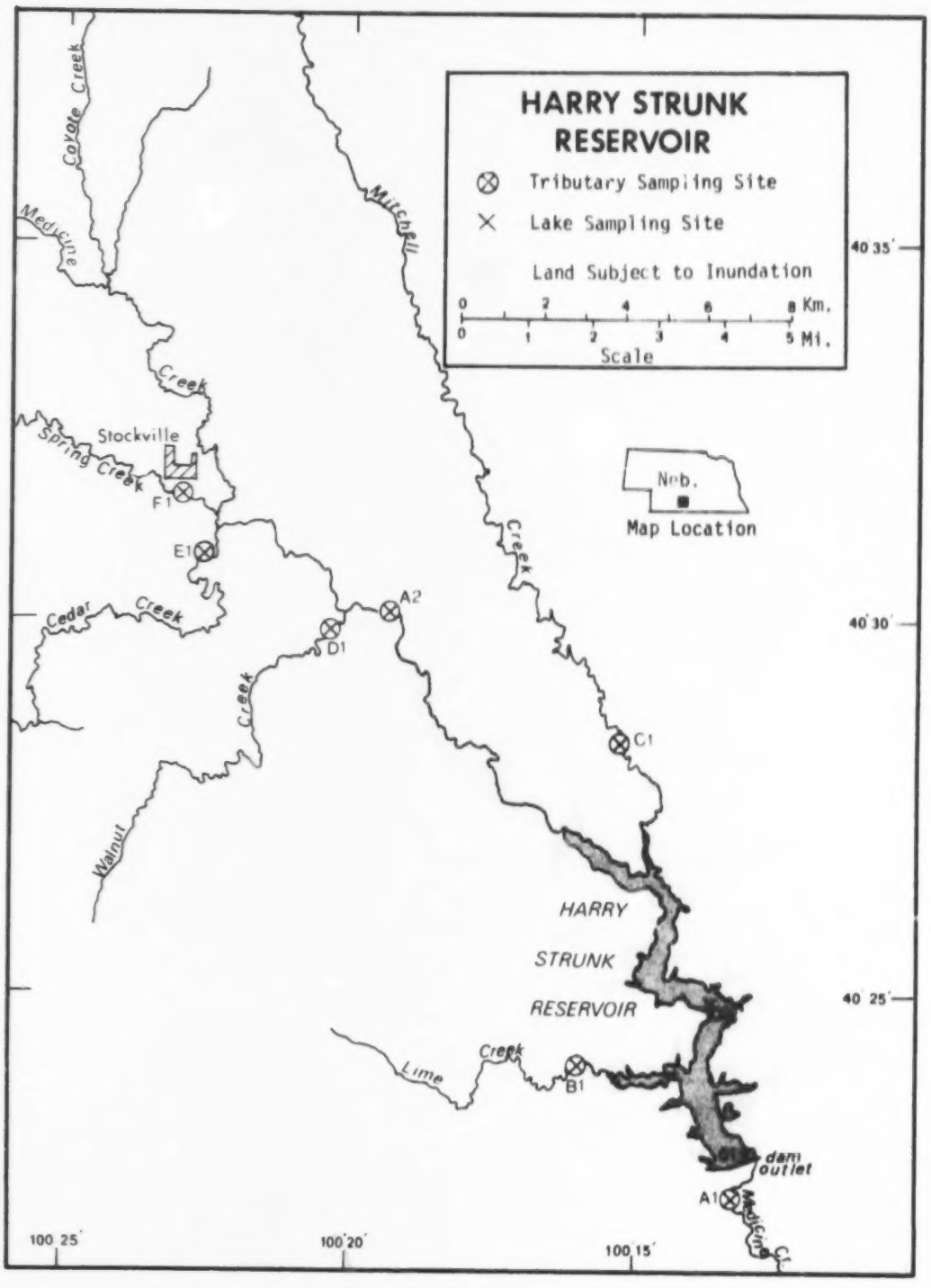
The staff of the Water Pollution Control Division, Department of Environmental Control, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

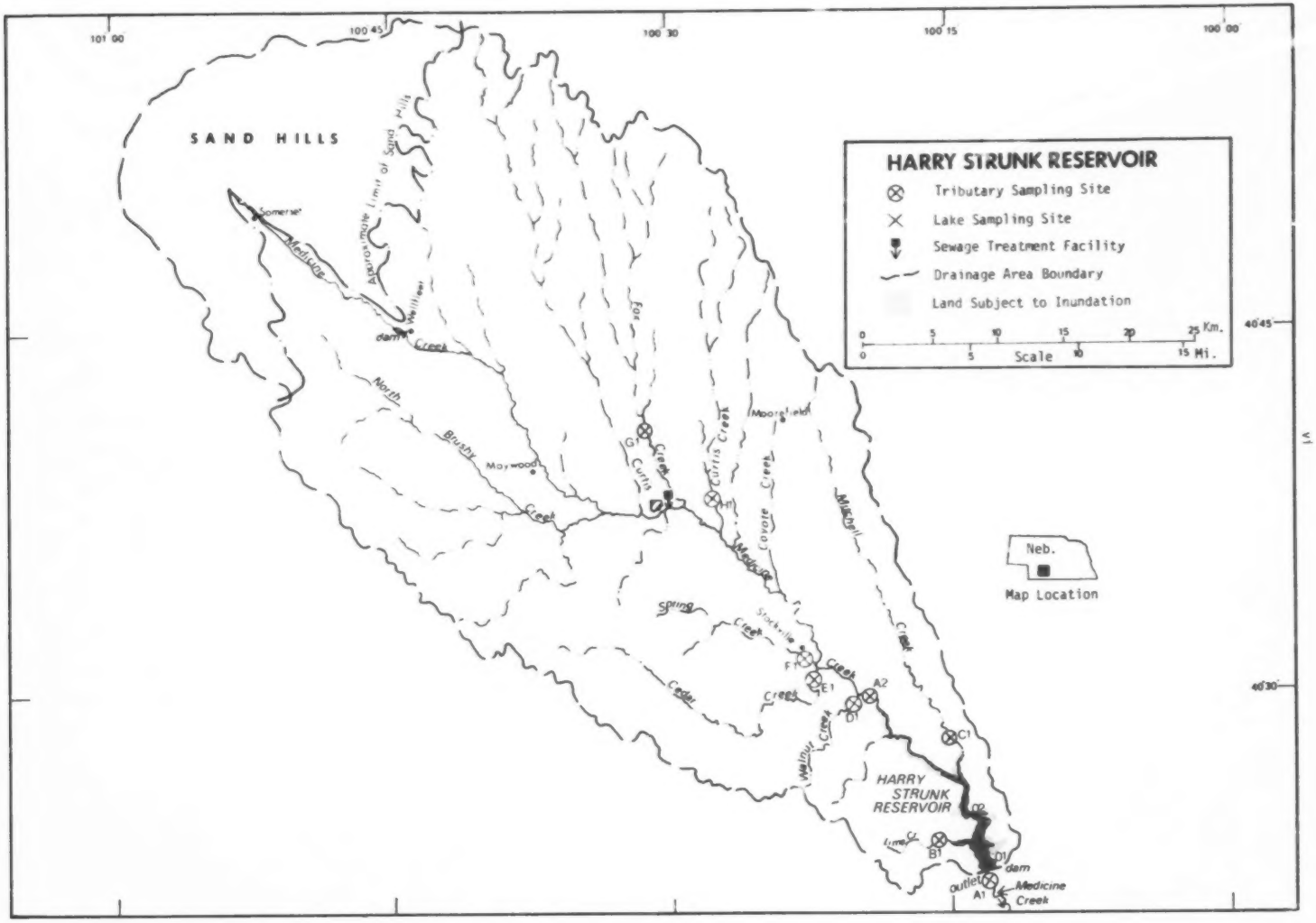
Major General Francis L. Winner, the Adjutant General of Nebraska, and Project Officer Colonel Burl M. Johnson, who directed the volunteer efforts of the Nebraska National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STATE OF NEBRASKA

RESERVOIR NAME	COUNTY
Branched Oak	Lancaster
Harlan County	Harlan
Harry D. Strunk	Frontier
Hugh Butler	Frontier, Red Willow
Johnson	Dawson, Gosper
McConaughy	Keith
Pawnee	Lancaster
Sherman	Sherman
Swanson	Hitchcock


HARRY STRUNK RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Land Subject to Inundation
0 2 4 6 8 Km.
0 1 2 3 4 5 Mi.
Scale
Neb.
Map Location
Coyote Creek
Medville
Mitchell
Creek
Stockville
Spring Creek
F1
E1
Cedar Creek
A2
D1
Walnut Creek
C1
HARRY
STRUNK
RESERVOIR
Lime Creek
B1
dam outlet
A1
Medicine Cr.
40 35'
40 30'
40 25'
100 25'
100 20'
100 15'


HARRY STRUNK RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Drainage Area Boundary
Land Subject to Inundation
0 5 10 15 20 25 Km.
0 5 Scale 10 15 Mi.
Neb.
Map Location
SAND HILLS
Approximate Limit of Sand Hills
Somerset
Medicine
Willow
dam
Creek
North
Brushy
Maywood
Creek
Moorefield
Curtis Creek
Coyote Creek
Mitchell
Creek
Spring
Creek
Stockville
Creek
Cedar
Creeks
Walnut
Creek
HARRY
STRUNK
RESERVOIR
Lime Cr.
dam
Medicine
Creek
outlet
G1
H1
F1
E1
A2
D1
C1
B1
D2
A1
101 00
100 45
100 30
100 15
100 00
40 45
40 30

HARRY D. STRUNK RESERVOIR

STORET NO. 3103

I. CONCLUSIONS

A. Trophic Condition

Survey data indicate Harry D. Strunk Reservoir is eutrophic. It ranked seventh in overall trophic quality when the nine Nebraska reservoirs sampled in 1974 were compared using a combination of six lake parameters*. Four of the reservoirs had less median total phosphorus, one had less and one had the same median dissolved phosphorus, seven had less median inorganic nitrogen, two had less mean chlorophyll a, and six had greater mean Secchi disc transparency. Depression of dissolved oxygen with depth occurred at both stations in July.

Survey limnologists noted an algal bloom along the north shore near sampling station 2 in September, and the phytoplankton data indicate bloom conditions in April (see page 6).

B. Rate-Limiting Nutrient:

The algal assay results indicate the reservoir was limited by phosphorus at the time the sample was collected (04/16/74). The reservoir data indicate phosphorus limitation in April and September.

C. Nutrient Controllability:

1. Point sources--It is calculated that known point sources contributed about 3% of the total phosphorus load to

---

* See Appendix A.

Strunk Reservoir during the sampling year. The Curtis municipal wastewater treatment plant was the major contributor.

During the sampling year, the reservoir received a total phosphorus loading over eleven times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 11). Therefore, it is unlikely that removal of phosphorus at the Curtis wastewater treatment plant would result in significant improvement in the trophic condition of the reservoir.

2. Non-point sources--It is estimated that non-point sources contributed about 97% of the total phosphorus load to the reservoir during the sampling year. Medicine Creek contributed 80.5% of the total load. Apparently, a significant reduction in the phosphorus loading to the reservoir can be achieved only through non-point-source control in the Medicine Creek drainage.

The phosphorus export rate of Medicine Creek was 27 kg/km^2 during the sampling year (see page 10). This rate is about twice that of Red Willow Creek, a tributary of nearby Hugh Butler Reservoir*, and about 13 times that of the Republican River at the inlet of Swanson Reservoir**.

* Working Paper No. 557.
** Working Paper No. 562.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry (at normal pool level)††:

1. Surface area: 7.49 kilometers^2.
2. Mean depth: 5.8 meters.
3. Maximum depth: 20.1 meters.
4. Volume: 43.442 x 10^6 m^3.
5. Mean hydraulic retention time: 280 days (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Medicine Creek	1,372.7	1.99
Minor tributaries & immediate drainage -	277.4	0.14
Totals	1,650.1	2.13

2. Outlet -

Medicine Creek	1,657.6**	1.96

C. Precipitation***:

1. Year of sampling: 57.6 centimeters.
2. Mean annual: 56.8 centimeters.

---

† Table of metric conversions--Appendix B.
†† Anonymous, 1975; Hartung, 1974.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of reservoir.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Harry D. Strunk Reservoir was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at two stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll *a* analysis. The maximum depths sampled were 9.1 meters at station 1 and 10.7 meters at station 2.

The sampling results are presented in full in Appendix D and are summarized in the following table (the July nutrient samples were not properly preserved and were not analyzed).

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR HARRY D. STRUNK (MEDICIN
STONET CODE 3103

PARAMETER	1ST SAMPLING (4/16/74) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (7/ 1/74) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (9/27/74) 2 SITES RANGE	MEAN	MEDIAN
TEMP (C)	8.3 - 8.6	8.4	8.4	18.8 - 23.7	22.0	22.6	16.6 - 17.3	16.9	16.6
DISS OXY (MG/L)	10.4 - 10.8	10.6	10.6	0.8 - 9.4	6.5	7.4	7.6 - 10.8	8.9	8.4
CNDCTVY (MCROMO)	43. - 215.	133.	132.	379. - 400.	393.	398.	185. - 346.	278.	333.
PH (STAND UNITS)	8.1 - 8.5	8.4	8.4	7.9 - 8.8	8.3	8.4	8.1 - 8.4	8.2	8.2
TOT ALK (MG/L)	173. - 176.	174.	174.	****** -**********			200. - 284.	231.	202.
TOT P (MG/L)	0.037 - 0.064	0.047	0.045	****** -**********			0.086 - 0.104	0.094	0.092
ORTHO P (MG/L)	0.005 - 0.010	0.007	0.007	****** -**********			0.008 - 0.033	0.023	0.026
NO2+NO3 (MG/L)	0.410 - 0.440	0.432	0.435	****** -**********			0.240 - 0.380	0.319	0.360
AMMONIA (MG/L)	0.030 - 0.050	0.037	0.040	****** -**********			0.020 - 0.080	0.053	0.060
KJEL N (MG/L)	0.580 - 0.880	0.612	0.600	****** -**********			0.600 - 1.400	0.814	0.700
INORG N (MG/L)	0.440 - 0.490	0.470	0.475	****** -**********			0.260 - 0.460	0.371	0.420
TOTAL N (MG/L)	0.940 - 1.210	1.045	1.035	****** -**********			0.950 - 1.640	1.133	0.980
CHLRPYL A (UG/L)	13.0 - 17.2	15.1	15.1	5.7 - 13.4	9.5	9.5	17.7 - 19.2	18.4	18.4
SECCHI (METERS)	0.3 - 0.7	0.5	0.5	1.3 - 1.5	1.4	1.4	0.3 - 0.4	0.3	0.3

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/16/74	1. Asterionella sp.	62,062
	2. Centric diatoms	4,124
	3. Dactylococcopsis sp.	3,921
	4. Flagellates	2,434
	5. Cryptomonas sp.	270
	Other genera	271
	Total	73,082
07/01/74	1. Aphanizomenon sp.	1,596
	2. Melosira sp.	726
	3. Cryptomonas sp.	522
	4. Fragilaria sp.	319
	5. Schroederia sp.	203
	Other genera	262
	Total	3,628
09/27/74	1. Stephanodiscus sp.	3,654
	2. Kirchneriella sp.	775
	3. Crucigenia sp.	664
	4. Cryptomonas sp.	277
	5. Synedra sp.	277
	Other genera	775
	Total	6,422

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
04/16/74	1	17.2
	2	13.0
07/01/74	1	6.7
	2	13.4
09/27/74	1	17.7
	2	19.2

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.005	0.397	0.1
0.050 P	0.055	0.397	13.1
0.050 P + 1.0 N	0.055	1.397	18.9
1.0 N	0.005	1.397	0.1

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Harry D. Strunk Reservoir was low at the time the assay sample was collected (04/16/74). Also a significant increase in yield with the addition of phosphorus alone indicates that the reservoir was limited by phosphorus at that time. Note that the addition of nitrogen alone resulted in a yield no greater than that of the control.

The reservoir data further indicate phosphorus limitation; i. e., the mean inorganic nitrogen/orthophosphorus ratios at both stations were 15/1 or greater in April and September.

IV. NUTRIENT LOADINGS
See Appendix E for data)

For the determination of nutrient loadings, the Nebraska National Guard attempted to collect monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the high runoff month of May, when the sites were visited twice. Sampling was begun in August, 1974, and was completed in June, 1975. Because of insufficient flows, no samples were collected at the sampling sites on Mitchell and Spring creeks during the sampling year.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Nebraska District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in $kg/km^2/year$, at station A-2 and multiplying the means by the ZZ area in km^2.

The operator of the Curtis wastewater treatment plant provided an insufficient number of monthly effluent samples and corresponding flow data; nutrient loads were estimated at 1.134 kg P and 3.401 N/capita/year, and flows were estimated at 0.3785 m^3/capita/day.

Results of analyses of the Curtis samples are included in Appendix E.

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* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Curtis	1,166	trickling filter	441.3	Medicine Creek

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (non-point load) -		
Medicine Creek	36,935	80.5
b. Minor tributaries & immediate drainage (non-point load) -	7,490	16.3
c. Known municipal STP's -		
Curtis	1,320	2.9
d. Septic tanks** -	5	<0.1
e. Known industrial - None	-	-
f. Direct precipitation*** -	130	0.3
Total	45,880	100.0

2. Outputs -

Lake outlet - Medicine Creek 2,725

3. Net annual P accumulation - 43,155 kg.

* Treatment plant questionnaire.
** Estimate based on nine lakeshore dwellings; see Working Paper No. 175.
*** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Medicine Creek	208,170	79.3
b. Minor tributaries & immediate drainage (non-point load) -	42,165	16.1
c. Known municipal STP's -		
Curtis	3,965	1.5
d. Septic tanks* -	95	<0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	8,085	3.1
Total	262,480	100.0

2. Outputs -

Lake outlet - Medicine Creek 112,530

3. Net annual N accumulation - 149,950 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Medicine Creek	27	152

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Lime Creek	0.106	3.207
Cedar Creek	0.132	2.367
Fox Creek	0.137	2.738
Walnut Creek***	2.100	3.710

* Estimate based on nine lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.
*** Based on one sample; no flow on any other sampling occasion.

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	6.13	5.76	35.0	20.0

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Harry D. Strunk Reservoir:

"Dangerous" (eutrophic loading)	0.54
"Permissible" (oligotrophic loading)	0.27

V. LITERATURE REVIEWED

Anonymous, 1975. Water resources data for Nebraska: Part 1 - Surface water records. U.S. Geol. Surv., Lincoln.

Hartung, Ray, 1974. Personal communication (lake morphometry). NE Dept. of Env. Contr., Lincoln.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
3101	BRANCHED OAK	0.044	0.070	456.444	17.033	9.400	0.013
3102	HARLAN COUNTY RESERVOIR	0.112	0.365	476.111	27.822	12.200	0.061
3103	HARRY D. STRUNK (MEDICIN	0.064	0.460	470.500	14.367	14.200	0.009
3104	HUGH BUTLER (RED WILLOW)	0.061	0.090	468.875	16.612	14.400	0.014
3105	JOHNSON RESERVOIR	0.075	0.340	477.667	26.133	8.600	0.009
3106	LAKE MCCONAUGHY	0.027	0.585	409.555	8.644	11.400	0.004
3107	PAWNEE LAKE	0.060	0.175	453.000	15.367	8.800	0.020
3108	SHERMAN COUNTY RESERVOIR	0.067	0.090	451.167	6.717	11.800	0.050
3110	SWANSON RESERVOIR	0.067	0.090	466.333	14.450	11.000	0.016

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
3101	BRANCHED OAK	88 (7)	100 (8)	63 (5)	25 (2)	75 (6)	63 (5)	414
3102	HARLAN COUNTY RESERVOIR	0 (0)	25 (2)	13 (1)	0 (0)	25 (2)	0 (0)	63
3103	HARRY D. STRUNK (MEDICIN	50 (4)	13 (1)	25 (2)	75 (6)	13 (1)	81 (6)	257
3104	HUGH BUTLER (RED WILLOW)	63 (5)	75 (5)	38 (3)	38 (3)	0 (0)	50 (4)	264
3105	JOHNSON RESERVOIR	13 (1)	38 (3)	0 (0)	13 (1)	100 (8)	81 (6)	245
3106	LAKE MCCONAUGHY	100 (8)	0 (0)	100 (8)	88 (7)	50 (4)	100 (8)	438
3107	PAWNEE LAKE	75 (6)	50 (4)	75 (6)	50 (4)	88 (7)	25 (2)	363
3108	SHERMAN COUNTY RESERVOIR	38 (3)	75 (5)	88 (7)	100 (8)	38 (3)	13 (1)	352
3110	SWANSON RESERVOIR	25 (2)	75 (5)	50 (4)	63 (5)	63 (5)	38 (3)	314

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	3106	LAKE MCCONAUGHY	438
2	3101	BRANCHED OAK	414
3	3107	PAWNEE LAKE	363
4	3108	SHERMAN COUNTY RESERVOIR	352
5	3110	SWANSON RESERVOIR	314
6	3104	HUGH BUTLER (RED WILLOW)	264
7	3103	HARRY D. STRUNK (MEDICIN	257
8	3105	JOHNSON RESERVOIR	245
9	3102	HARLAN COUNTY RESERVOIR	63

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR NEBRASKA 12/23/75

LAKE CODE 3103 HARRY STRUNK RES.

TOTAL DRAINAGE AREA OF LAKE(SQ KMI 1657.6

TRIBUTARY	SUB-DRAINAGE AREA(SQ KMI	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
3103A1	1657.6	0.74	1.16	1.76	1.61	2.24	3.91	5.38	3.85	1.88	0.51	0.57	0.62	1.96
3103A2	1372.7	1.59	2.18	2.35	1.98	2.72	3.54	2.27	1.39	1.39	1.44	1.61	1.59	1.99
3103ZZ	284.9	0.01	0.08	0.14	0.03	0.31	0.57	0.34	0.15	0.07	0.01	0.0	0.0	0.14

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 1657.6
SUM OF SUB-DRAINAGE AREAS = 1657.6
TOTAL FLOW IN = 25.66
TOTAL FLOW OUT = 23.47

NOTE *** TOTAL 4 ZZ DR. AREAS DIRECTLY CONTRIBUTING. 880 SQ. MI. TOTAL AREA.

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3103A1	8	74	2.19	25	2.27				
	9	74	0.04	8	0.07				
	10	74	0.06	6	0.06				
	11	74	0.03	16	0.03				
	12	74	0.05	7	0.05				
	1	75	0.05	5	0.05				
	2	75	0.05	9	0.05				
	3	75	0.02	22	0.03				
	4	75	0.02	19	0.02				
	5	75	0.38	4	0.02				
	6	75	3.79	7	0.68				
3103A2	8	74	0.74	25	0.74				
	9	74	0.89	14	0.93				
	10	74	1.27	15	1.33				
	11	74	1.48	27	1.47				
	12	74	1.37	26	1.16				
	1	75	1.64						
	2	75	1.53	21	1.93				
	3	75	1.88	15	1.73				
	4	75	1.79	13	1.76				
	5	75	1.54	4	1.56	17	1.73		
	6	75	4.81	18	3.28				
3103ZZ	8	74	0.0	25	0.0				
	9	74	0.0	14	0.0				
	10	74	0.0	15	0.0				
	11	74	0.0	27	0.0				
	12	74	0.0	26	0.0				
	1	75	0.0						
	2	75	0.0	21	0.0				
	3	75	0.0	15	0.0				
	4	75	0.0	13	0.0				
	5	75	0.0	4	0.0	17	0.0		
	6	75	0.57	18	0.71				

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/12/23

310301
40 22 48.0 100 13 00.0
HARRY D. STRUNK (MEDICINE CREEK)
31063 NEBRASKA

11EPALES 2111202
3 0038 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/04/16	09 55	0000	8.5		28	43	8.50	173	0.030	0.700	0.430	0.010
	09 55	0005	8.4	10.8		90	8.40	173	0.040	0.500	0.440	0.006
	09 55	0015	8.3	10.6		165	8.40	174	0.030	0.600	0.430	0.005
	09 55	0030	8.3	10.6		190	8.15	173	0.040	0.600	0.430	0.010
74/07/01	10 15	0000	22.8	7.4	60	400	8.50					
	10 15	0005	22.7	7.4		397	8.50					
	10 15	0011	22.6	7.0		393	8.40					
	10 15	0020	21.1	0.8		390	8.00					
	10 15	0030	19.3	2.4		379	8.10					
74/09/27	15 45	0000	16.6	8.0	14	338	8.09	202	0.060	1.000	0.360	0.032
	15 45	0005	16.6	8.4		335	8.16	201	0.080	0.600	0.380	0.032
	15 45	0015	16.6	7.8		204	8.16	200	0.060	0.600	0.380	0.033
	15 45	0028	16.6	7.6		185	8.14	201	0.060	0.600	0.370	0.019

32

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/16	09 55	0000	0.040	17.2	
	09 55	0005	0.037		
	09 55	0015	0.038		
	09 55	0030	0.043		
74/07/01	10 15	0000		5.7	
	10 15	0005			50.0
	10 15	0011			1.0
74/09/27	15 45	0000	0.090	17.7	
	15 45	0002			1.0
	15 45	0005	0.090		
	15 45	0015	0.092		
	15 45	0028	0.104		

STORET RETRIEVAL DATE 75/12/23

310302
40 24 51.0 100 13 38.0
HARRY D. STRUNK (MEDICINE CREEK)
31063 NEBRASKA

11EPALES 2111202
3 0040 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/04/16	10 20	0000	8.6		12	97	8.40	176	0.030	0.800	0.410	0.006
	10 20	0005	8.4	10.6		99	8.40	175	0.040	0.500	0.440	0.007
	10 20	0015	8.4	10.4		165	8.40	175	0.040	0.600	0.440	0.007
	10 20	0035	8.3	10.4		215	8.40	174	0.050	0.600	0.440	0.008
74/07/01	10 45	0000	23.7	9.0	50	399	8.80					
	10 45	0005	23.7	9.2		398	8.60					
	10 45	0010	23.3	7.8		396	8.50					
	10 45	0020	22.0	9.4		395	8.10					
	10 45	0030	18.8	4.2		381	7.90					
74/09/27	16 15	0000	17.3	10.8	13	346	8.38	268	0.050	0.700	0.250	0.008
	16 15	0005	17.3	9.4		333	8.40	284	0.040	0.800	0.250	0.009
	16 15	0018	17.3	10.4		204	8.40	264	0.020	1.400	0.240	0.026

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/16	10 20	0000	0.052	13.0	
	10 20	0005	0.053		
	10 20	0015	0.047		
	10 20	0035	0.064		
74/07/01	10 45	0000		13.4	
74/09/27	16 15	0000	0.103	19.2	
	16 15	0003			1.0
	16 15	0005	0.086		
	16 15	0018	0.093		

APPENDIX E

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 76/01/27

3103A1
40 22 20.0 100 13 20.0
MEDICINE CREEK
31083 7.5 CAMBRIDGE
O/HARRY STRUNK RESERVOIR
BANK SAMP OFF END OF RD .5 M S MED CR DM
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/08/25	14	20	0.352	0.500	0.030	0.025	0.075
74/09/08	14	20	0.400	0.400	0.020	0.040	0.065
74/10/15	14	20	0.432	0.800	0.040	0.035	0.090
74/11/16	14	20	0.576	0.900	0.032	0.035	0.070
74/12/07	14	20	0.440	0.800	0.020	0.010	0.060
75/01/05	14	20	0.640	3.200	0.208	0.015	0.040
75/02/09	14	20	0.640	0.900	0.048	0.016	0.030
75/03/22	14	20	0.660	0.900	0.025	0.040	0.040
75/04/19	14	20	0.480	1.300	0.045	0.010	0.060
75/05/04	14	20	0.320	0.900	0.100	0.010	0.040
75/06/07	14	20	0.105	0.887	0.280	0.025	0.042

STORET RETRIEVAL DATE 76/01/27

3103A2
40 30 10.0 100 19 20.0
MEDICINE CREEK
31 7.5 STCKVILLE SE
T/HARRY STRUNK RESERVOIR
BANK SAMP OFF END OF RD 4 M SE STOCKVILE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/08/25	14 50		0.830	1.500	0.045	0.030	0.240
74/09/14	13 50		1.440	1.200	0.055	0.060	0.190
74/10/06	13 05		1.200	1.150	0.090	0.040	0.210
74/11/27	10 55		1.100L	0.700	0.024	0.064	0.180
74/12/26	11 35		2.240	0.600	0.050	0.065	0.090
75/02/21	10 00		2.090	1.300	0.128	0.072	0.370
75/03/15	12 05		1.820	1.100	0.134	0.082	0.380
75/04/13	11 00		1.600	1.330	0.260	0.085	0.370
75/05/04	10 30		1.200	1.880	0.190	0.075	0.440
75/05/17	15 45		1.450	0.600	0.025	0.115	0.437
75/06/18	14 20		1.450	3.900	0.045	0.220	1.550

L ACTUAL VALUE IS KNOWN TO BE
GREATER THAN VALUE GIVEN

STORET RETRIEVAL DATE 76/01/27

310381
40 24 00.0 100 23 26.0
LIME CREEK
31 7.5 FREEDOM
T/HARRY STRUNK RESERVOIR
SEC RD BRDG 3.8 M NW OF MEDICINE CR DAM
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/08/25	13 50		2.300	0.700	0.080	0.071	0.125
74/09/14	13 55		2.400	0.900	0.075	0.060	0.090
74/10/06	13 55		1.920	1.100	0.030	0.055	0.090
74/11/16	13 55		2.730	0.600	0.025	0.045	0.070
74/12/07	13 55		2.460	0.500	0.020	0.030	0.050
75/01/05	13 55		2.760	2.100	0.040	0.030	0.040
75/03/21	13 55		1.530	1.550	0.030	0.051	0.230
75/04/19	13 55		1.570	1.400	0.085	0.060	0.110
75/05/04	13 55		1.150	0.950	0.160	0.035	0.090
75/06/18	13 55		1.450	2.000	0.450	0.095	0.170

STORET RETRIEVAL DATE 76/01/27

310301
40 29 53.0 100 20 25.0
WALNUT CREEK
31 7.5 FREEDOM
T/HARRY STRUNK RESERVOIR
SEC RD XING 3.5 MI SE OF STOCKVILLE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
75/06/18	10 55		0.410	3.300	0.175	0.450	2.100

STORET RETRIEVAL DATE 76/01/27

3103E1
40 41 43.0 100 22 35.0
CEDAR CREEK
31 7.5 STOCKVILLE
T/HARRY STRUNK RESERVOIR
SEC RD BRDG 1.2 MI S OF STOCKVILLE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/08/24	14 20		0.520	0.700	0.030	0.025	0.075
74/09/14	13 30		1.240	0.500	0.020	0.010	0.035
74/10/15	12 35		1.320	1.000	0.040	0.015	0.050
74/11/17	10 30		1.920	0.500	0.035	0.010	0.020
75/02/21	09 50		1.860	1.400	0.040	0.024	0.050
75/03/15	11 55		1.400	2.700	0.138	0.024	0.350
75/04/13	10 50		1.500	1.350	0.340	0.035	0.100
75/05/06	10 10		0.510	1.450	0.155	0.025	0.160
75/05/17	15 25		0.400	0.400	0.032	0.015	0.108
75/06/18	10 45		1.650	1.350	0.050	0.105	0.370

STORET RETRIEVAL DATE 76/01/27

310361
40 42 10.0 100 31 15.0
FOX CREEK
31 FRONTIER CO HWY
T/HARRY STRUNK RESERVOIR
SEC RD BRDG 6.5 MI W OF MOOREFIELD
11EPALES 2111204
4 0000 FEET DEPTH

	DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
W	74/08/24	13 30		1.900	0.500	0.035	0.110	0.160
O	74/09/14	12 50		2.080	1.000	0.095	0.070	0.140
	74/10/15	11 10		1.680	0.600	0.025	0.075	0.090
	74/11/27	09 10		1.100L	0.400	0.032	0.048	0.075
	74/12/26	09 40		2.640	0.800	0.020	0.035	0.050
	75/02/21	09 00		2.255	0.600	0.040	0.050	0.060
	75/03/15	11 20		2.090	0.750	0.038	0.049	0.080
	75/04/13	10 15		1.720	1.550	0.145	0.095	0.130
	75/05/06	09 30		1.100	1.300	0.210	0.115	0.150
	75/05/17	14 30		1.300	0.450	0.040		0.030
	75/06/18	10 00		2.100	2.200	0.310	0.240	0.540

L ACTUAL VALUE IS KNOWN TO BE
GREATER THAN VALUE GIVEN

STORET RETRIEVAL DATE 76/01/27

3103AA TF3103AA P001166
40 30 00.0 100 30 30.0
CURTIS
31 7.5 CURTIS NE
T/HARRY STRUNK RESERVOIR
MEDICINE CREEK
11EPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
75/06/09	10 00		13.000	9.200	0.100	9.300	11.000	0.050	0.050
75/07/09	15 00		11.500	15.500	2.700	9.600	10.500		
75/07/23	08 30		10.000	6.600	0.250	10.500	11.450		
W 75/08/06	08 30		11.000	9.800	0.084	9.700	9.900		
75/08/15	11 50		11.500	3.500	0.180	10.500	12.200	0.060	0.074
75/08/29	08 30		13.200	19.500	3.850	11.500	13.000		
75/09/03	08 30		11.500	13.500	0.280	10.000	11.000		
75/09/17	08 00		7.860	15.000	0.300	11.000	12.500		
75/10/01	08 30		9.200	8.200	0.320	11.000	12.500		
75/10/15	08 30		12.600	17.500	2.200	12.000	14.500		
75/11/12	08 30		10.000	21.000	7.200	11.500	11.500		
75/11/26	08 30		7.500	21.000	7.600	11.500	18.500		